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Reducing Graphene-Metal Contact Resistance via Laser Nano-welding

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MOTIVATION AND CHALLENGES

- The large graphene-metal contact resistance is a major limitation for development of graphene electronics.
- Graphene behaves as an insulator for out-of-plane carrier transport to metallic contacts.

PROPOSED SOLUTION

Laser nano-welding of graphene to the metal contacts

- Laser-induced formation of defects.
- Increase the chemical reactivity of graphene.
- Avoid unwanted damage to channel region.
- Realization of a strong G-M bonding at laser-induced defects.

METHODS

I. Fabrication of the four-point probe structures

II. Laser nano-welding of graphene

A. Laser irradiation
- Wavelength: 514 nm.
- Laser Fluence: 1.6×10^4 J/cm^2.

B. Thermal annealing
- Temperature: 400 °C.
- Time: 1 hr.
- Pressure: 1-5 mTorr (Ar purge).

RESULTS AND DISCUSSION

I. Reducing the Contact resistance via laser nano-welding

- Slight increase in $R_c$ for all samples after the laser-irradiation.
- Significant reduction of $R_c$ values after the annealing.
- $R_c$ values as low as 2.57 $\Omega \mu m$ obtained via laser nano-welding method.

II. Structural characterization using $I_D/I_G$ Raman mapping

- A rise in the $I_D/I_G$ ratio was observed only at the edges of graphene, where laser irradiation was performed.
- No change was observed at the channel region and the middle of graphene-metal interface.
- Performance degradation was avoided, due to selective mechanism of the laser-irradiation.

III. Carrier mobility

- Slight reduction in the mobility after the laser irradiation.
- Increased mobility after the thermal annealing.
- Improved carrier injection efficiency, due to the bonding formation at the edges of graphene.

CONCLUSIONS

- Laser nano-welding was developed and led to $R_c$ reductions of up to 84%.
- Localized laser irradiation at the edges of graphene led to the formation of chemically active point defects.
- Precise structural modifications and formation of G-M bonding led to improved carrier efficiency in graphene devices.

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